THE HARNESSING OF THE RENEWABLE ENERGY SOURCES POTENTIAL OF THE REPUBLIC OF MOLDOVA

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Ensuring energy needs has turned into a major topic of all socio-economic systems worldwide. Against this background, renewable energy sources become a powerful part of the national, regional and global security. Given the current global trends and the major dependence on imports of energy resources in Moldova, a new strategy must be adopted by upgrading existing energy infrastructure, internal energy market analysis, diversification of the existing renewable energy sources and permanent coordination of the decisions taken within national energy policies. In this article, the author examined the potential of the renewable energy sources available in the Republic of Moldova, presenting calculations on the effectiveness of these resources use.

Key words: *security, energy, renewable energy sources, economics, strategy, globalization, biomass.*

Asigurarea necesarului de energie s-a transformat într-un subiect major al tuturor sistemelor economico-sociale mondiale. Pe acest fundal, sursele de energie regenerabilă se afirmă puternic ca o latură aparte a securităţii naţionale, regionale şi globale. Având în vedere tendinţele actuale globale şi dependenţa majoră a Republicii Moldova faţă de importurile de resurse energetice, se impune adoptarea unei noi strategii prin modernizarea infrastructurii energetice actuale, analiza pieţei interne de energie, diversificarea surselor de energie regenerabilă existente şi coordonarea permanentă a deciziilor luate în cadrul politicilor energetice la nivel naţional. În prezentul articol, autorul a examinat potenţialul surselor de energie regenerabilă disponibile în RM, prezentând calcule referitoare la eficacitatea utilizării acestor resurse.

Cuvinte cheie: *securitate, energie, surse de energie regenerabilă, economie, strategie, globalizare, biomasă.*

Обеспечение потребности в энергии превратилась в одну из самых обсуждаемых тем социально-экономических систем во всем мире. На этом фоне, возобновляемые источники энергии выделяется в качестве отдельной категории национальной, региональной и глобальной безопасности. Учитывая текущие мировые тенденции, а также большую зависимость Молдовы в импорте энергоносителей, рекомендуется изменить национальную энергетическую стратегию путем модернизации существующей энергетической инфраструктуры, анализа внутреннего энергетического рынка, диверсификации существующих источников энергии и постоянной координации принимаемых решений национальной энергетической политики. В этой статье, автор рассмотрел потенциал возобновляемых источников энергии доступных в стране, представляя расчеты по эффективному использованию этих ресурсов.

Ключевые слова: *безопасность, энергетика, возобновляемые источники энергии, экономика, стратегия, глобализация, биомасса.*

JEL Classification: F52; F59; F62; O11; Q2; Q42.

Introduction. In recent decades, gradually diminishing of the natural resources, the worsening climate conditions and the demographic explosion justify seeking solutions to reduce dependence on the imports of primary energy resources, to improve the security of supply and to combat the climate change. Using an increasingly higher degree of the renewable energy sources and applying environmentally friendly technologies represent significant contributions to sustainable development. In addition, it may contribute to ensuring the welfare and for a better quality of life for the future generations.

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Harnessing the potential of the renewable energy sources gives real premises for achieving strategic objectives on increasing security of energy supply through diversification and decreasing the share of energy resources imports, respectively, for an environmental protection and sustainable development of the energy sector.

Renewable energy sources and energy efficiency are a relatively new area for Moldova, but with a huge potential for development. In order to promote energy efficiency projects and actions, a very important role is palyed by the existence of the legal framework, so the basic law in this area was adopted only in 2010. If the country is a net importer of energy resources, the renewable sources and energy efficiency is the sustainable solution for strengthening energy security and for reducing the economic effects caused by more expensive imported resources.

Table 1 shows the available technical potential of the main types of renewable energy resources in Moldova, which is estimated at 2709 thousand toe. This potential could fully satisfy the energy demand of the national economy and exclude imports overall energy bill.

The energy potential of biomass. The Moldovan government has committed to reform the energy sector by increasing energy security, diversification of energy sources and attracting investments in this sector. The authorities are opting for an increase of up to 20%, by 2020, the share of energy produced from renewable sources in the total structure of energy consumption in Moldova, objective contained in the country's energy strategy. The most abundant alternative energy source in Moldova is biomass. According to the definition contained in the European Directive 2003/30/EC: *Biomass means the biodegradable fraction of products, waste and residues from biological origin from agriculture, forestry, related industries and municipal waste [8, p. 7]*.

Table 1

Available technical potential of the main types of renewable energy resources

Type		Technical potential	
		PJ	**thou. t.o.e.**
Solar		50,4	1 204
Wind		29,4	702
Hydro		12,1	289
Biomass	Agricultural waste	7,5	179
	Firewood	4,3	103
	Waste from processing wood	4,7	112
	Biogas	2,9	69
	Biofuel	2,1	50
	Total biomass	21,5	514
Total potential renewable energy sources		**113,4**	**2 709**
The annual energy consumption of Moldova		**102,5**	**2 442**

Source: Adapted by author based on Moldovan Energy Strategy 2020 [11] and the Energy Balance of the Republic of Moldova [1].

As Moldova is an agrarian country, then obviously exploiting the potential of existing biomass is one of the great challenges of our country. The biomass can be used for producing of heating, cooling, electricity and biofuel used in transport. Plants do not require a particular space, they can be located outdoors not far from the building which is to be supplied with heat.

The use of biomass significantly reduces greenhouse gas emissions. The carbon dioxide which it releases during the combustion of biomass is offset by the amount absorbed until the plant cultivation.

The use of biomass is the most economically efficient way to diversify the consumed energy resources. Therefore, are welcomed the actions taken by the Government of Moldova in recent years on the launch of public – private partnerships, meant to harness the potential of biomass. In Table 2 were performed calculations on the cost of production of a Gcal of heat energy, using different energy sources. Compared to the tariff set by "Termocom" JSC (987 lei / Gcal), more economically efficient production costs of a Gcal is the using of the wood as energy resource (399 lei / Gcal), briquettes (417 lei / Gcal), coal (427 lei / Gcal) and natural gas (840 lei / Gcal). The use of gasoline, diesel and liquefied petroleum

gas is expensive and can be recommended only in cases where there is no access to other energy resources. "Termocom" JSC distributes heat produced by the CHP using natural gas. Based on calculations (Table 2) it is recorded a difference of about 147 lei / Gcal between the cost of producing a Gcal obtained from natural gas and the supply price of "Termocom" JSC. The difference can be explained by high transportation costs, high losses in the network caused by aging infrastructure and poor performance of the energy efficiency of buildings.

Table 2

Costs of the production of a Gcal of heat energy, using various energy sources (in current prices for 01.09.2014)

Energy Sources	Current tariff	Calorific value	The cost of production of a Gcal of heat energy
Wood (spruce)	700 lei/m^3	3 900 kcal/kg	399
Briquettes and pellets	**2000 lei/ ton**	**4 800 kcal/kg**	**417**
Coal	3200 lei/ ton	7 500 kcal/kg	427
Natural Gas	6718 lei/ 1000 m^3	8 000 kcal/m^3	840
Liquefied petroleum gas	9,97 lei/liter	6 070 kcal/liter	1 643
Diesel	17,37 lei/liter	8 774 kcal/liter	1 980
Gasoline	18,37 lei/liter	8 437 kcal/liter	2 177
Heat supplied by "Termocom" JSC	**987 lei/Gcal**	**–**	**987**

Source: Adapted by the author [13].

At the same time calculations demonstrate the effectiveness of the use of biomass heating installations, particularly in the rural areas, in the buildings with a large area (eg.: schools, kindergartens, administrative buildings, etc.).

Solar energy. Solar power systems don't produce noise or emissions and use free fuel – the sunlight. Because they don't contain moving parts, the maintenance of these systems does not require large expenditures. Photovoltaic systems use cells that are manufactured form semiconductor material to convert sunlight into electricity. When the light hits the cell, it produces a magnetic field, which creates a flow of electrons or electricity.

Solar energy resources in Moldova are higher in the south of the country and decrease constant towards the north. In Moldova the possible (theoretical) duration of the sunshine is 4445-4452 hours per year. The real duration of the sunshine represents 47-52% or 2 100-2 300 h of the possible [3, p. 508].

A system with installed capacity of 1 kW (continuous current peak capacity) with unclouded and fixed mount, that requires about 6.5 m^2 of modules, will produce between 1 050 and 1 200 kWh per year [12]. With the wear of modules, the production decreases at an annual average of 0.7% [5, p. 5]. In 2013 the installation costs of photovoltaic systems ranged between 2000 and 3000 Euro per kW, excluding the land price and network connection costs. After 2010, the price of solar electricity fell rapidly. Annual maintenance costs are about 0.01 Euro per kWh. The necessary land for photovoltaic plants is approximately 2.5 ha for 1 MW of installed capacity [9, p. 101].

By performing calculations on the opportunity of developing the solar energy industry in Moldova we can conclude that:

- The high cost of photovoltaic technology determines the production cost of 1 kwh to be the greatest of all generation sources (Table 2).
- At current tariffs established by NAER (1.92 lei / kWh), an investment in solar energy could be recovered for 23 years. Given the realities and economic conditions in Moldova, both local businesses and foreign investors are still not likely to make such long-term investments. Therefore all attempts to develop this sector are very limited from installed capacity and geographical perspective.
- Global trends of cheapening the technologies used in the production of photovoltaic modules

create prerequisites for the development of this industry in the national economy. Thus solar energy has great potential for development in Moldova in the near future.

Wind energy. A wind turbine is the opposite of a fan. Instead of using electricity to make wind, how does the fan, wind turbines use wind to make electricity. The blades of the wind turbine are rotating under the force of the wind by turning a gear box connected to an electric generator, thereby producing electricity. Wind energy is a function of the square of its speed. Thus, if the wind speed increases twice, then generated electricity grow quadruple.

The turbines are best placed in high places, in the open ground, with good access for vehicles and near transmission lines that have available capacity. The hub of the wind turbine should be located at 30 meters above the all objects within a radius of 300 meters.

Wind power plants have a relatively small impact on the environment; some people are concerned about the noise from the rotor blades, aesthetic impact (visual) and the impact on birds and bats which hit the blades. Most of these problems can be solved or considerably reduced through the proper placement of wind farms. The cost of wind turbines ranges between 300 Euro and 500 Euro per 1 kW of installed capacity. The maintenance costs are between 0.01 and 0.03 Euro per 1 kWh produced. Wind complexes need about 15 hectares per 1 MW of installed power [9, p. 97].

Moldova has a favorable wind potential for the efficient functioning of wind turbines. National statistics data describe that in the nineteenth century windmills were widely spread in Bessarabia [6, p. 12]. Respectively, Moldova has a technical wind potential of 1 GW, which could produce 2.2 TWh per year (assuming an average annual capacity factor of 0.25). The average annual wind speed in Moldova is from 3 to 4 meters per second, a wind resource quoted from moderate to weak.

As in the case of solar energy, the wind energy represents a new underdeveloped area, but with great exploration potential in the future. From the economic point of view, the use of wind turbines is more attractive than PV panels. Thus performing calculations on the opportunity of developing the wind energy sector of renewable energy in Moldova we can conclude:

- The cost of producing of 1 kWh through wind turbines is competitive with the electricity distribution companies tariffs (Table 2).
- At current tariffs established by NAER (1.24 lei / kWh), an investment in the wind energy could be recovered just for 5 years. Thus, economic premises and weather conditions in Moldova predisposing toward exploiting the wind potential (702,000 toe) [11], namely the development and strengthening this sector of the renewable energy.

Hydroelectric energy. The basic principle of hydraulic energy is that the water pressure can rotate an electric generator. The use of water energy is one of the most efficient in terms of cost and safety of applied technology, at the same time generating "clean" electricity.

Small hydropower plants, less than 100 kW, are often used because their costs are reduced, require small storage ponds and dams, are easily connected to the network, do not require great effort for maintenance, are relatively simple to install and are suitable for local implementation and management. Other benefits of small hydro power plants include:

- The conversion efficiency is between 70% and 90%, being the best of all energy production technologies.
- A high degree of predictability, which varies according to the annual rainfall regime, so the variability of the output power, is low.
- Robust technology with an operating period of 50 years.

The main disadvantage related to the construction of dams is causing the damage for rivers and lakes, as the water flow affects and destabilizes their ecosystems. The quantity (kW) of hydro energy (P) produced is determined by the volume of water flow (Q) in cubic meters per second, water fall (H) in meters (i.e., the distance between the surface and the turbine) and the power efficiency (e), taking into account the frictional losses in the dam and efficiency of the turbine and the generator (e.g., 85% efficiency = 0.85).

$$P = Q \times H \times e \times 9.81 \text{ kW} \quad (1)$$

The small hydropower plants have an installation cost from 200 000 to 5 million Euro per MW (on average of 1.3 mln. Euro per MW). The operating and maintenance costs are approximately 25 000 Euro per MW per year, which corresponds to the experience of some projects in the Balkan countries [9, p. 98].

The Republic of Moldova has a historical experience of use rivers energy, thus according to statistics, in 1901 in Bessarabia were recorded about 1,000 small capacity water mills [4, p. 8]. Although

Moldova has a large number of rivers, the potential for energy production is relatively small. Currently, there are only two major hydropower plants. One of the most feasible and profitable projects in Moldova would be the obtaining energy by using Nistru and Prut water through installation of small hydropower plants. For example, the waters of the Nistru river are quite stable (7 km/h), which avoids the instability of tension, respectively to achieving high quality energy, which demonstrates the profitability of such local projects. Also, due to the small thickness of the ice of Nistru and Prut rivers in the winter, as well as the short period of its presence, demonstrates that the functionality of these plants is possible all year around [2, p. 36]. Thus, a calculation of the return on investment in hydropower equipment (Table 3) demonstrates that such investments could be recovered just in 3-4 years. In the following calculations were ignored the costs of land location, construction and installation the equipment to produce electricity. In this way, the creation of public-private partnerships in the field of renewable energy production would strengthen this sector perspective, by minimizing the costs for equipment placement and ensuring the long-term investment recovery.

Finally, performing an analysis of the potential use of renewable energy in electricity production from economic point of view, were made the following findings:

- The high cost of photovoltaic technology determines the lowest competitiveness of the solar energy in the "green" energy market;
- The cheapest electric power is produced from hydraulic energy. However, the construction of accumulation lakes, beside great economic efforts involves some environmental risks.
- The best in terms of price and mobility can be considered the exploration of the wind energy.

Table 3

Production cost of a kWh of electricity, using various energy sources (connected in terms of return on investment into production equipment), lei / kwh

Energy sources	Tariffs established by NAER	5 years	10 years	15 years	20 years	25 years	30 years
Solar energy	**1,92**	8,20	4,19	2,86	2,19	1,79	1,52
Wind energy	**1,24**	1,23	0,89	0,78	0,72	0,69	0,67
Hydropower	**0,17**	0,75	0,41	0,29	0,24	0,20	0,18
RED Nord-Vest	**1,73**	-	-	-	-	-	-
RED-Nord	**1,71**	-	-	-	-	-	-
RED Union Fenosa	**1,58**	-	-	-	-	-	-
Imports from Ukraine	**1,00***	-	-	-	-	-	-

****- Imports of electricity are carried out at the price of 0.069 USD / kWh. The MDL conversion was made at the official exchange rate of the Moldavian National Bank of 14.53 lei / USD on 24.09.2014***
Source: Prepared by author [9].

For large-scale popularization and implementation of renewable energy technologies is needed to create a regulatory framework and favorable economic and financial conditions. In particular it requires the harmonization of national legislation with the European regarding the use of renewable energy. Many EU countries establish guaranteed prices (feed-in tariffs, FIT), through which companies operating electricity networks are compelled to purchase the entire quantity of electricity produced from renewable sources at a higher price than conventionally produced electricity. The Feed-in Tariffs differ depending on renewable energy technology, capacity and location. Currently, existing special tariffs for electricity produced from renewable energy sources in Moldova are established by NAER Decisions, based on the weighted average cost of capital (WACC) for each economic agent in part [10]. Thus, both existing tariffs and the way of their establishing do not stimulate "green" energy development in the country. The uncertainty of the medium and long-term investments recovery cannot be regarded as an incentive for the development of this industry. In addition, in the European practice there are extensive policies of subsidizing or at least facilities (incentives) for the import tax of the "green" energy production equipment [7, p. 21-23].

Conclusions. The developing of using the renewable energy resources is a priority for government policies and strategies of the Republic of Moldova. The enormous dependence on imported energy resources and the general trend of increasing energy prices create a favorable environment for the development of alternative energy sources. The "green" energy development would increase the resilience of the energy security of country to exogenous factors influence, would create new jobs, added value to the national economy and develop technology transfer.

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